Chapter 1
Introduction and Background

In this chapter, we provide a summary of legislation, NPS policy and guidance, Service-wide and Network-specific strategic goals for performance management, and park-enabling legislation relevant to vital signs monitoring. The monitoring framework adopted by SWAN is outlined, along with monitoring questions that drove the selection of vital signs.

1.1 The Importance of Long-Term Monitoring

Park managers entrusted with stewardship of our public lands have long known that decisionmaking related to protecting these ecosystems is complex. They need relevant, up-to-date information to understand how the condition of park resources is changing over time in response to natural processes and human activities. In 1992, the National Research Council (1992) reviewed the natural resource management program of the NPS and concluded that "if the National Park Service is to meet the scientific and resource management challenges of the twenty-first century, a fundamental metamorphosis must occur within its core." Indeed, that metamorphosis materialized when the NPS implemented a strategy to standardize inventories and monitoring of natural resources on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based, managerial decision making and resource protection. The national strategy consists of a framework having three major components:

1. Completion of basic natural resource inventories in support of future monitoring efforts;
2. Creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and
3. Implementation of operational vital signs monitoring in all natural resource parks.

A fundamental goal of the NPS is to protect or maintain natural ecosystem structure and function in national parklands. Alaska national park units are among the last remaining wilderness areas in the world—large enough to support naturally occurring ecological and evolutionary processes. These parks have been viewed as ecological baseline controls that provide us with unique insights into the functioning of ecosystems, in which the effects of humans are minimized (Arcese and Sinclair 1997).

> *"And so we might continue to ask questions, the answers to which would be sought by National Park Service scientists were there a formal, continuing, and sufficiently massive program of ecological and systematic monitoring."*
> *(Cain 1959)*

Knowing the condition of natural resources in national parks is crucial to the Service's ability to protect and manage parks. National park managers across the country confront increasingly complex and challenging issues and are asked to provide scientifically credible data to defend management actions. Many of the threats to park resources, such as invasive species and air and water pollution, come from outside the park boundaries, and so require a landscape approach (see Section 1.8.1) and integrated long-term monitoring to understand and protect the park's natural resources.

In this plan, we define vital signs monitoring as "the collection and analysis of repeated observations or measurements to evaluate ecological changes in the condition of park resources" (see Glossary). In theory, by monitoring a wide range of variables at long-term sites, it is possible to gain an understanding of how ecosystems function and respond to change (Bricker and Ruggiero 1998). Coupling monitoring with research and modeling may make it possible to predict what will happen in the future and, if necessary, devise appropriate response strategies.

Ecological monitoring is vital to park management for a variety of reasons:

- Ecological monitoring can provide important understanding and insights into long-term ecological phenomena and the functioning of complex ecosystems across park and Network boundaries.
- Ecological monitoring is necessary to evaluate objectively whether the NPS is achieving mandates and policies of protecting park natural resources. One of the major shortcomings of most natural resource management and conservation plans has been the absence of a comprehensive ecological monitoring program (Kremen et al. 1994).
- Ecological monitoring is necessary to detect and evaluate the long-term adverse effects of human activities on park ecosystems. Because of the delay between a human disturbance and a subsequent response, long-term ecological monitoring is necessary to detect change.
- Information that flows from ecological monitoring elevates the stature of park ecosystems, organisms, and ecological processes to stakeholders, park visitors, and the public.

1.2 NPS Policies and Mandates that Link Monitoring and Management of Parks

The enabling legislation establishing the NPS and its individual park units clearly mandates, as the primary objective, the protection, preservation, and conservation of park resources, in perpetuity for the use and enjoyment of future generations (NPS 1980). NPS policy and recent legislation (National Parks Omnibus Management Act of 1998) require that park managers know the condition of natural resources under their stewardship and monitor long-term trends in those resources to fulfill the NPS mission of conserving parks unimpaired (Figure 1-1; see Summary of Laws, Policies, and Guidance). The laws and management policies that follow provide the mandate for inventories and monitoring in national parks.

The mission of the NPS (NPS Organic Act, 1916) is:

> "*...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental*

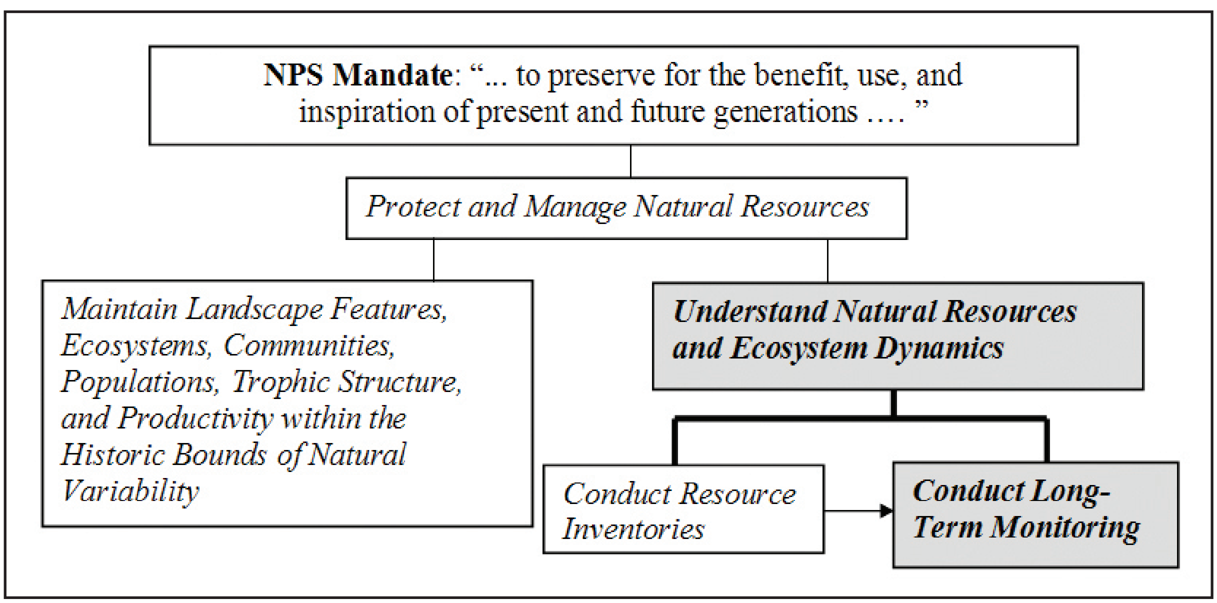

Figure 1-1 *Relationship between park mandates, resource protection, and long-term monitoring.*

purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Congress strengthened the NPS's protective function and provided language important to recent decisions about resource impairment when it amended the Organic Act in 1978 to state that *"the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…."*

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. The act charges the Secretary of the Interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System,*" and to *"assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the act requires the Secretary of the Interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriation Bill:

> *"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."*

The 2001 NPS Management Policies updated previous policy and specifically directed the Service to inventory and monitor natural systems:

> *"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."*
>
> Further, *"The Service will:*
>
> - *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents.*
> - *Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources.*
> - *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals.*
> - *Analyze the resulting information to detect or predict changes, including interrelationships with*

visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames.

- *Use the resulting information to maintain-and, where necessary, restore the integrity of natural systems" (2001 NPS Management Policies).*

Additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks, and specifically guide the natural resource management of Network parks include the following:

- Taylor Grazing Act 1934;
- Fish and Wildlife Coordination Acts, 1958 and 1980;
- Wilderness Act 1964;
- National Historic Preservation Act 1966;
- National Environmental Policy Act of 1969;
- Clean Water Act 1972, amended 1977, 1987;
- Endangered Species Act 1973, amended 1982;
- Migratory Bird Treaty Act, 1974;
- Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976;
- Mining in the Parks Act 1976;
- American Indian Religious Freedom Act 1978;
- Archaeological Resources Protection Act 1979;
- Federal Cave Resources Protection Act 1988;
- Clean Air Act, amended 1990; and
- Wild and Scenic River Act 1990.

1.3 Applications of Information Gained from Monitoring: Who Is Interested in the Information Provided by Monitoring and Why?

The most widely identified application of monitoring is that of enabling managers to make better informed management decisions (White and Bratton 1980, Croze 1982, Jones 1986, Davis 1989, Quinn and van Riper 1990). For example, monitoring rates of coastal shoreline erosion and accretion can help park managers assess risks to archeological sites or aid in decisions regarding the placement of backcountry cabins or other structures.

Monitoring provides a tool to address issues that occur at multiple sites in a park or multiple parks within a network, rather than addressing site-specific problems individually. From such a holistic view, managers can develop general principles and guidelines that can be applied broadly to a particular type of issue.

In large wilderness park units, an important application of monitoring information is simply to gain insight into how complex park ecosystems function (Croze 1982). By gathering data over long periods, correlations between different attributes (such as predator and prey populations) become apparent, and resource managers gain a better general understanding of the ecosystem. In turn, this knowledge may support future decisions concerning existing or proposed harvest levels for a species.

Similarly, some authors suggest that it is important to document changes for the sake of familiarity with the resources (Halvorson 1984, Croze 1982). The responsibility of resource managers includes an awareness of changes in resources under their stewardship, even if no specific management decisions or actions are involved. For example, a park may want to monitor succession in areas where glaciers are retreating even if resource managers do not contemplate active management of the vegetation.

Another use of monitoring information involves convincing others to make decisions benefiting national parks (Johnson and Bratton 1978, Croze 1982). Some aspects of monitoring may focus on documenting specific internal or external threats. For example, parks and neighboring coastal landowners may monitor concentrations of hydrocarbons in benthic invertebrates to document the effects of offshore oil and gas activities on nearshore intertidal communities. In that case, the information may convince local governments, Native corporations, industries, or even courts of law to make decisions benefiting national parks.

Monitoring sensitive species, wilderness-dependent species, or entire communities in relatively undisturbed wilderness park units can provide park managers, stakeholders, and the public with a kind of “canary in the mine”—an early warning of the effects of human activities before they become noticeable in more impacted areas (Davis 1989, Wiersma 1984). For example, locations initially free from local sources of pollution may show a more pronounced response to the effects of long-range transport and deposition of air pollutants than adjacent developed areas.

Finally, a monitoring program can provide basic background information that is needed by park researchers, public information officers, interpreters, and those wanting to know more about the area around them (Johnson and Bratton 1978). Data such as basic weather information, plant phenology, and records of major disturbances, such as volcanic eruptions and landslides, are useful on a periodic basis to those working or visiting in the parks.

1.4 Southwest Alaska Network—Environmental Setting and Park-Specific Mandates: What Physical and Biological Features Make These Park Units Special?

The Southwest Alaska Network (SWAN) consists of five units of the NPS (Figure 1-2, Appendix I-1). Katmai National Park and Preserve (KATM) (6,409 mi^2 [16,599 km^2]), Alagnak Wild River (ALAG) (48 mi^2 [124 km^2]), and Aniakchak National Monument and Preserve (ANIA) (942 mi^2 [2,440 km^2]; Appendix I-2) are managed as one administrative unit by staff based in King Salmon. Lake Clark National Park and Preserve (LACL) (6,254 mi^2 [16,198 km^2]) is managed by staff based in Anchorage, Homer, and Port Alsworth, and Kenai Fjords National Park (KEFJ) (1,047 mi^2 [2,712 km^2]) is managed by staff based in

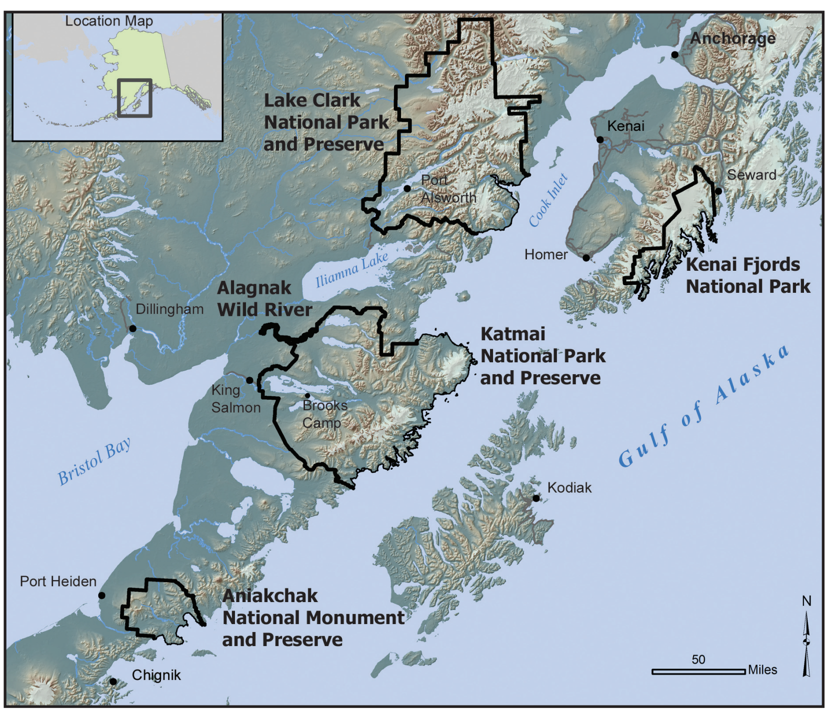

Figure 1-2 *National Park Service units in SWAN.*

Seward. Collectively, these units comprise 9.4 million acres (3.8 million hectares), 11.6 percent of the land managed by the NPS, or 2 percent of the Alaska landmass, and include a diversity of geologic features, ecosystems, wildlife, and climate conditions that are equaled few places in North America (Appendix II).

> ***Mandate: Aniakchak National Monument and Preserve*** -
> *"To maintain the caldera and its associated volcanic features and landscape, including the Aniakchak River and other lakes and streams, in their natural state; to study, interpret, and assure continuation of the natural processes of biological succession; to protect habitat for, and populations of, fish and wildlife, including, but not limited to, brown/grizzly bears, moose, caribou, sea lions, seals, and other marine mammals, geese, swans, and other waterfowl…." (Alaska National Interest Lands Conservation Act* [ANILCA]).

1.4.1 Dynamic Landform Processes and Patterns

From steep glaciated fjords in the east to steaming volcanoes on the western horizon, SWAN parks occur in one of the most geologically active regions of the continent. The Network is located on the shelf of the North American Plate, one of the most seismically active regions of the United States. During the 1964 earthquake, lands within KEFJ subsided three to six vertical feet (0.9 to 1.8 meters), whereas in LACL and KATM, coastal lands rose by that amount. The Network contains at least 17 active volcanoes. Katmai National Monument was created to preserve the Valley of Ten Thousand Smokes, a spectacular 40-square mile, 100-to-700-foot-deep, pyroclastic ash flow deposited by the 1912 eruption of Novarupta. Aniakchak National Monument was created in recognition of the unique geological significance of its 6-mile-wide, 2,000-foot-deep caldera formed 3,500 years ago by the explosive eruption of a 7,000-foot mountain.

Approximately one-fifth of the landmass of this Network is covered by ice or permanent snowfields. Valley and tidewater glaciers radiate from massive snowfields along the coastal mountains of the three northernmost parks. Ten of the 34 tidewater and hanging glaciers that emanate from the Harding Icefield are in KEFJ.

Volcanic eruptions, tectonic forces, and glacial processes combine to make this Network an important laboratory for both geologic research and long-term ecological studies of how landscapes respond to infrequent, large-scale disturbances. For example, a unique opportunity exists to observe pattern and relative timing of ice retreat, primary and secondary plant succession, patterns of animal colonization, and evolutionary processes.

> ***Mandate: Kenai Fjords National Park*** –
> *"To maintain unimpaired the scenic and environmental integrity of the Harding Icefield, its outflowing glaciers, and coastal fjords and islands in their natural state; and to protect seals, sea lions, other marine mammals, and marine and other birds and to maintain their hauling and breeding areas in their natural state, free of human activity which is disruptive to their natural processes."* (ANILCA)

1.4.2 Marine Coastline

SWAN parks contain almost one-third of the marine coastline in the National Park System. This coastline spans 1,200 miles in the northern Gulf of Alaska, from the heavily glaciated KEFJ on the Kenai Peninsula to sparsely glaciated Aniakchak on the Alaska Peninsula. The Network's varied coastline, numerous freshwater drainages, and diverse geomorphology generate many combinations of physical factors, creating a microcosm of the northern Gulf of Alaska. KEFJ's rocky headlands with extreme wave exposure place in sharp contrast the protected low-energy beaches and broad intertidal flats at KATM and LACL.

SWAN coastal waters are one of the most biologically productive nearshore ecosystems in the world (Sambrotto and Lorenzen 1986). High tides, frequent storms, and upwelling produced by the Alaska Coastal Current bring essential nutrients to the surface euphotic zone, where they support growth and productivity along the continental shelf (Burbank 1977, Lees et al. 1980, Hood and Zimmerman 1986).

Important ecological features of the Network coastline include (i) sheltered salt marshes and tidal flats that support lush vegetation and large populations of benthic organisms and serve as important feeding and resting areas for brown bears (*Ursus arctos horribilis*), shorebirds, and fish; (ii) cliffs, headlands, and islands that support seabird rookeries and marine mammal haul outs; (iii) eelgrass, surfgrass, and kelp beds that provide herring spawning areas and a nursery substrate that supports the base of the nearshore food chain; and (iv) tidally influenced coastal freshwater streams that support wild stocks of anadromous salmon.

1.4.3 Aquatic Systems, Anadromous Fish, and Ecological Interrelationships

***Mandate: <u>Lake Clark National Park and Reserve</u>** – "To protect the watershed necessary for the perpetuation of the red salmon fishery in Bristol Bay; to maintain unimpaired the scenic beauty and quality of portions of the Alaska Range and the Aleutian Range, including volcanoes, glaciers, wild rivers, lakes, waterfalls, and alpine meadows in their natural state; to protect habitats for and populations of fish and wildlife, including, but not limited to caribou, Dall sheep, brown/grizzly bears, bald eagles, and peregrine falcons."* (ANILCA)

Wild anadromous fishes link the ocean, freshwater, and land in important functional ways, supporting a complex food web that crosses the land-water interface (Willson et al. 1998). The interrelation-ships among salmon (*Oncorhynchus* sp.*)*, brown bears, and the structure and function of both aquatic and terrestrial ecosystems are flagship ecological resources of the Network and of national and international significance.

Network parks contain some of the largest and most pristine freshwater resources in the National Park System. These include the two largest lakes, Naknek Lake and Lake Clark, numerous multilake systems, and thousands of miles of rivers, including five designated Wild Rivers. Surface water covers approximately 432,000 acres (12 percent) of KATM. Aquatic systems in the western portions of KATM and LACL are so extensive that they form the template upon which biological systems at all levels are organized.

Aquatic systems in the Network are pristine in the sense that (i) natural watershed processes are operating, including disturbances such as floods and seasonal changes in flow; (ii) water quality is, by national standards, unimpaired (there are no designated [303(d), Clean Water Act] surface waters, although near-field and far-field influence have in all likelihood introduced small but unknown amounts of contaminants; and (iii) aquatic fauna diversity and productivity vary naturally in both time and space. Aquatic and terrestrial animals have likely had a very long, and probably coevolutionary, relationship with salmon in each of these parks (Willson et al. 1998, Gende 2002, Schindler et al. 2003), as higher growth rates or reproductive successes in eagles, bears, and mink have been attributed to salmon availability (Hansen 1987, Ben-David 1997, Hilderbrand et al. 1999b). The magnitude of salmon-wildlife-ecosystem relationships calls attention to the consequences of loss or severe depletion of anadromous fish stocks, and the role that long-term monitoring can play in documenting these changes.

1.4.4 Wilderness-Dependent Large Mammal Species and Species Interactions

***Mandate: <u>Katmai National Park and Preserve</u>** – "for the protection of the ecological and other scientific values of Naknek Lake and the existing monument…; to protect habitats for, and populations of, fish and wildlife, including, but not limited to, high concentrations of brown/grizzly bears and their denning areas; to maintain unimpaired the water habitat for significant salmon populations; and to protect scenic, geological, cultural, and recreational features."* (ANILCA)

Despite hunting and other human activities, all parks in the Network possess intact, naturally functioning terrestrial ecosystems with their historic complement of species, including large apex carnivores and predator-predator, predator-prey interactions. Intact, functioning ecosystems with historic levels of biodiversity are becoming extremely rare globally and supply a resource of great value locally and internationally.

Some key wilderness-dependent mammals in SWAN are wolverines *(Gulo gulo*), brown bears, wolves *(Canis lupus*), and lynx *(Lynx rufus*). These species do not require wilderness habitats per se, but they require wilderness to avoid conflicts with humans and to avoid human-caused mortality. They also depend on populations of free-roaming, naturally cycling prey. Wilderness-dependent interactions include wolf-ungulate, brown bear-ungulate, carnivore-carnivore, predator-scavenger, and cyclic lynx-snowshoe hare (*Lepus americanus)* interactions.

Davis and Halvorson (1988) considered national park ecosystems to be "miner's canaries," and nowhere is this con-cept more appropriate than when applied to wilderness-dependent species (Peek 1999). Because such species are sensitive to human disturbance and need large tracts of wild land or wilderness to survive, their status signals impending environmental change across broad geographic areas. For example, wolverines are a classic wilderness-dependent species because they require large home ranges with a full array of seasonal habitats, intact populations of prey, larger apex predators that provide scavenging opportunities, and refugia from human influences. Banci (1994) found that the persistence of wolverines in southwestern Alberta is due entirely to the presence of large refugia in the form of national parks. As wild ecosystems are progressively compromised by a variety of human activities, such as mining, logging, recreation, and settlement, what is left becomes increasingly valuable as laboratories of natural ecological processes.

1.4.5 Ecoregion and Biological Diversity

Mandate: __Alagnak Wild River__ *– "To protect and enhance the values which caused it to be included in said system.…These values are the river's outstandingly remarkable scenic, fish and wildlife, and recreation attributes."* (ANILCA)

Southwest Alaska parks are places where land and water meet. LACL is often called "one park, four Alaskas," referring to the diversity of landscapes relative to area (Appendix I-2, I-3, and I-4). Although not as dramatically, this diversity feature is shared by each of the Network parks, which collectively span three Alaska climatic zones and 11 ecoregions (Appendix I-5).

Landscape diversity, the product of diverse bedrock types and climatic and disturbance regimes, provides the template for relatively high biological diversity. Coastal Aleutian, low Arctic, interior-boreal, and Pacific coastal floras and faunas converge in southwest Alaska, with SWAN parks supporting 60% of the state's vascular plant flora. Vascular plant communities in the region continue to undergo changes in composition, and the shift in species distributions since the Last Glacial Maximum, primarily in the movement of species south and southwest, is readily observed today. For example, Sitka spruce (*Picea sitchensis*) is migrating from the upper Alaska Peninsula west toward the Aleutians and southwest toward the Kodiak Island Archipelago (Capps 1937), while alder (*Alnus sinuata*) has increased dramatically in the region over the last several centuries (Heusser 1983, Nelson 2004). Numerous species of animals, such as Dall sheep *(Ovis dalli),* black bear *(Ursus americanus*), and trumpeter swans *(Olor buccinator),* also reach the limits of their statewide range in SWAN parks.

Climate change and its influence on the distribution of plants and animals in the Network have broad implications for long-term monitoring. The geographic ranges of most plant and animal species are limited by climatic factors, including temperature, precipitation, soil moisture, humidity, and wind. Peninsular landmasses are likely to respond to climate change more rapidly and severely than mainland interior areas because of a greater coast/interior ratio (Suffling and Scott 2002). Colonization by new species, changes in the distribution of existing species, or changes in the timing of critical life stages or patterns of migration all have implications for park management and resource protection.

1.5 Approach to Planning a Monitoring Program

SWAN staff have followed the basic three-phase, five-step approach to designing a monitoring program (Table 1-1), described in detail in the Recommended Approach for Developing a Network Monitoring Program (http://science.nature.nps.gov/im/monitor/index.htm):

Table 1-1 *Overall timeline for the SWAN to complete the entire three-phase planning and design process to develop a monitoring program.*

	FY01 Oct-Mar	FY01 Apr-Sep	FY02 Oct-Mar	FY02 Apr-Sep	FY03 Oct-Mar	FY03 Apr-Sep	FY04 Oct-Mar	FY04 Apr-Sep	FY05 Oct-Mar
Data Gathering, Internal Scoping									
Inventories to Support Monitoring									
Scoping Workshops									
Conceptual Modeling									
Vital Sign Prioritization and Selection									
Protocol Development, Monitoring Design									
Monitoring Plan Due Dates Phase 1, 2, 3					Phase 1 Oct 03		Phase 2 Oct 04		Phase 3 Dec 05

Phase 1

1. Define the purpose and scope of the monitoring program.
2. Compile and summarize existing data and understanding of park ecosystems.
3. Develop conceptual models of relevant ecosystem components.

Phase 2

4. Select vital signs and specific monitoring objectives for each.

Phase 3

5. Determine the appropriate sampling design and sampling protocols.

During March and May 2002, the SWAN Technical Committee held a series of meetings to develop a strategy for breaking the three-phase planning process into manageable pieces that could be addressed sequentially. Considerations in developing this strategy were (i) the relatively small size of the natural resources staff in the Network parks (at the onset of planning the combined natural resources staff of the three administrative units numbered seven); (ii) logistical challenges of meeting as a group because park staff are based in three different remote Alaska locations; and (iii) a desire by Technical Committee members to participate collectively as a single team throughout the planning process.

1.5.1 Scoping Workshops

The Technical Committee used a series of mini scoping workshops to review and discuss the current state of knowledge concerning park ecosystems, resource protection issues, and potential options for monitoring. The objectives for workshops were to (i) review/refine conceptual ecosystem models and monitoring questions drafted by the Technical Committee and Network staff; (ii) identify drivers of change and discuss why it is important to understand them; and (iii) identify candidate attributes to monitor that provide reliable signals about ecosystem condition. The Technical Committee, NPS staff from other networks and the Alaska Regional Office, and scientists from universities, State of Alaska agencies, and other federal agencies attended the workshops.

Figure 1-3 *Participants identify candidate attributes to monitor during the Terrestrial Ecosystems Workshop in 2003.*

Most workshops had a community or ecosystem focus, and workshops were ordered in sequence: coastal⇨ freshwater⇨ terrestrial (Figure 1-3, Table 1-2). The coastal workshop was held first because in this Network the ocean influences structure and processes in freshwater and terrestrial ecosystems. Similarly, the freshwater workshop identified many key terrestrial linkages, such as nutrient transfer. The cascading sequence also allowed many of the same participants to progress through the process in a logical order. The workshop summaries comprised a growing base of information that enhanced efficiency of successive workshops and integration of components. Pre-workshop preparation involved assembling extensive background material on Network parks and developing objectives and monitoring questions This background material was mailed to participants 1 month before the workshop to familiarize them with the landscape and to stimulate discussion.

Table 1-2 *Scoping workshops held in FY 2002–2003 to identify ecosystem drivers and other agents of change, resource management and scientific issues, and monitoring options for parks in the SWAN.*

DATE/PLACE	PARTICIPANTS[1]	SUBJECT	PURPOSE
May 2, 2002, in Anchorage, AK	Network Park Staff, Subject Matter Expert(s): Karen Oakley, USGS	Network Landscape Ecosystems	Identify: Dominant Resource Management Issues; Focus Areas for Long-term Monitoring, Physical and Human-related Agents of Change, and Landscape Sub-components to be Addressed by Subsequent Workshops
August 26–28, 2002, at Kenai Fjords National Park	Network Park Staff, Subject Matter Expert(s): Charles Peterson, Univ. North Carolina; Carl Schoch, Kachemak Bay Research Reserve-ADF&G; Vernon Byrd, Alaska Maritime NWR-USFWS; Karen Oakley, USGS; Peter Armato, NPS	Marine–Coastal Nearshore Ecosystems	Review: Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, Their Ecological Importance, and How They Are Affected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring
November 4–6, 2002, at Cooper Landing, AK	Network Park Staff, Subject Matter Expert(s): John Magnuson, Univ. Wisconsin; Robert Stallard, USGS-WRD, Joe Margraf, Univ. Alaska Fairbanks; Jim Larson, USFWS; Phil North, EPA; Karen Oakley, USGS; Nancy Deschu, NPS	Freshwater Ecosystems	Review: Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, Their Ecological Importance, and How They Are Affected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring
December 12, 2002, in Anchorage, AK	Network Park Staff, Subject Matter Experts: Michael Shephard, USFS; Karen Oakley, USGS	Physical Landscape Drivers	Review: Modify Landscape Conceptual Models; Identify Key Physical Drivers of Change and How They Are Manifested as Gradients of Temperature and Precipitation; Identify Catastrophic Disturbances
April 16–17, 2003, in Anchorage, AK	Network Park Staff, Subject Matter Expert(s): Robert Gill Jr., USGS; David Duffy, Pacific CESU; Rob DeVelice, USFS; Gerald Tande, ANHP; Ed Berg, USFWS; Torre Jorgenson, Alaska Biol. Research; Karen Oakley, USGS; Terry DeBruyn, NPS	Terrestrial Ecosystems—Fauna and Flora	Review: Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, Their Ecological Importance, and How They Are Affected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring
November 13, 2003, in Fairbanks, AK. Jointly held with Central Alaska Network	Network Park Staff, Subject Matter Expert(s): Bruce Molnia, USGS; Dennis Trabant, USGS; Rod March, USGS; Daniel Lawson, CRREL; Keith Echelmeyer, UAF-GI; Martin Treuffer, UAF-GI; Roman Motyka, UAF-GI; William Harrison, UAF-GI; Matthew Sturm, CRREL; Adam Bucki, UAF-GI	Glaciers and Icefields	Review: Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Components of Glacier Systems that are Effectively Monitored; Identify Potential Partnerships for Glacier Monitoring.

1. ADF&G - Alaska Department of Fish and Game; USFWS - U.S. Fish and Wildlife Service; USGS - U.S. Geological Survey; USFS - U.S. Forest Service; EPA - Environmental Protection Agency; CESU - Cooperative Ecosystems Study Unit; ANHP- Alaska Natural Heritage Program

Scoping workshop discussions were recorded and compiled into a workshop summary report that was sent to participants and posted on the Network Web site. Workshop notebooks and summary reports also were circulated for technical review and comment by scientists who did not attend the workshops (Table 1-3). Review comments were not used to revise the summaries, but were added as an attachment and were considered by the Technical Committee during Phase II planning.

Table 1-3 *Technical reviewers of SWAN scoping workshop summaries.*

Technical Reviewer and Affiliation(s)	Area(s) of Expertise
Ginny L. Eckert Assistant Professor of Biology University of Alaska, Southeast School of Fisheries and Ocean Sciences Juneau, AK	Marine Intertidal Ecology and Monitoring; Population Dynamics of Benthic Marine Invertebrates
Mark W. Oswood Professor of Zoology University of Alaska - Institute of Arctic Biology Bonanza Creek LTER Fairbanks, AK	Freshwater Ecology, Especially of Rivers and Streams; Limnology; Entomology; Biodiversity of Aquatic Invertebrates
Andrea Woodward Research Ecologist USGS FRESC Olympic Field Station Seattle, WA	Development of Long-Term Ecological Monitoring Plans; Plant-Animal Interactions; Effects of Climate Change on Subalpine Plant Communities
Michael Shephard Ecologist US Forest Service State and Private Forestry Anchorage, AK	Community Ecology; Dynamics of Coastal Rainforests; Ecoregion Mapping; Invasive Exotic Plants
John N. Schoen Senior Scientist National Audubon Society - Alaska State Office Affiliate Professor of Wildlife Biology University of Alaska Anchorage, AK	Large Mammal Population Dynamics; Forest Wildlife Habitat Relationship; Conservation of Landscape Biodiversity

1.5.2 Data Mining

The purpose of data mining was to find and catalog information relating to natural resources in the park or its vicinity to support the development of a monitoring plan. Products from data mining primarily consisted of two types of documentation: a bibliography and metadata. The bibliography documented formal and informal reports, articles, and books, whereas metadata information documented databases, geographic information system (GIS) data, and spreadsheets. Results from data mining are searchable using the SWAN Information Discovery and NPS NatureBIB (http://www1.nature.nps.gov/im/units/swan/).

1.5.3 Review of Monitoring by Others

To help us develop partnership opportunities or benefit from monitoring efforts conducted by other federal and state agencies, we reviewed global, national, regional, and local monitoring efforts that may be relevant to natural resources monitoring in our Network. A portion of this survey was accomplished using a questionnaire that was mailed to principal investigators. We compiled information into databases of existing and planned research and monitoring within ecoregions encompassed by the Network. Other partnership opportunities were identified during scoping workshops.

1.6 Water and Air Quality Monitoring

Issues affecting water quality, the role of water quality monitoring in an integrated ecosystem context, Water Resources Division (WRD) core variables, and other water quality parameters were discussed at the coastal, freshwater, and other scoping workshops. The Network's strategy for water quality monitoring (funded by the NPS WRD) is to fully integrate the design and implementation of water quality monitoring with the Network-based vital signs monitoring. Steps taken toward developing a water quality monitoring component include (i) identifying and evaluating existing monitoring efforts, historic data, and information needs; (ii) developing a list of biological, chemical, and physical parameters for monitoring; and (iii) determining watershed and water body features (Appendix I-6).

As part of these efforts, the Network has determined that no 303(d) waters are present in any of the parks, although several have been designated on tributaries to the Naknek River downstream of the park boundary. The State of Alaska does not designate Outstanding National Resource Waters. Water quality data collection within these parks has been sporadic, and trend analysis was not possible. In general, Network waters are low in nutrients and show little evidence of human impact. Some water bodies (e.g., Battle Lake, tributaries to Surprise Lake, and streams within the Valley of Ten Thousand Smokes) are naturally low in pH or are enriched in dissolved constituents due to volcanic inputs.

All parks within SWAN are classified as Class II air quality areas. Limited monitoring of fine particulates (< 2.5 µm) in KATM from 1987 to 1992 indicated sources from long-range transported anthropogenic aerosol, sea-salt aerosol, and local soil dust, and high concentrations of lead and bromide, indicative of fossil fuel emissions (Polissar et al. 1998). Potential air pollution threats include oil and gas development in Cook Inlet, mining, coal-fired power production, and long-range transport of air pollutants. The U.S. Fish and Wildlife Service has established two coastal Interagency Monitoring of Protected Visual Environments (IMPROVE) stations in the SWAN region, one along the coast of LACL, and a second in the Shumagin Islands, which should provide regional data on aerosol concentrations. In addition, the Western Airborne Contaminants Assessment Project (WACAP) has been initiated to determine the risk to ecosystems and food webs in western national parks from the long-range transport of airborne contaminants.

1.7 Monitoring Goals, Objectives, and Questions

The overall goals of natural resource monitoring in parks are to develop scientifically sound information on the current status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems (http://science.nature.nps.gov/im/monitor/GoalsObjectives.htm#GoalsObj).

NPS Service-wide Vital Signs Monitoring Goals

1. *Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.*
2. *Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.*
3. *Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.*
4. *Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.*
5. *Provide a means of measuring progress toward performance goals*

The long-term monitoring program of SWAN will be designed around the five broad, Service-wide goals. Service-wide goals 1 and 3 establish the primary framework for the monitoring in SWAN because they emphasize (i) the establishment of baseline reference conditions representing the current status of park and preserve ecosystems; and (ii) an understanding of the range of natural variation in park ecosystems and detecting changes through time.

Within coastal, freshwater, and terrestrial ecosystems, preliminary monitoring objectives and questions were nested within this framework of understanding ecosystem behavior and detecting change (Table 1-4). Objectives and questions were developed by the SWAN Technical Committee and revised based on review of conceptual ecosystem models, suggestions from scientists who participated in the scoping workshops, and comments from technical reviewers of the workshop summaries. These general monitoring questions served as the basis for framing more specific monitoring questions and measurable objectives that were incorporated into protocol development summaries after vital signs were selected.

Table 1-4 SWAN monitoring objectives and questions.

Climate and Weather
Objective 1. Understand the natural range of variation in weather patterns across the SWAN parks. • What is the annual variability in quantity, timing and form of precipitation in network park ecoregions? • What are the patterns of direction, strength, and timing for storm tracks and wind? How do these affect storm surges on coastal systems? • What are the ranges and timing of seasonal temperature fluctuations?
Objective 2. Understand general climate trends in network parks, including changes due to Pleistocene ice retreat and global climate change. • How are current climate trends contributing to glacial retreat (and possible advances)? • Are there general trends in warming (cooling) and/or increased (decreased) precipitation? Are these trends affecting volume and timing of river flows and coastal storms?
Dynamic Landform Processes and Patterns
Objective 1. Understand how movements of the North Pacific and North American plates are affecting park terrains. • How do ongoing earthquake activity and resultant uplift and subsidence affect park lands, especially coastal beaches and intertidal areas?
Objective 2. Understand effects of Pleistocene and Little Ice Age glaciations on SWAN ecosystems. • How rapidly are glaciers retreating now, relative to former eras? How are icefields changing in area and extent? • How are refugia and nunataks affecting patterns of plant and animal colonization?
Marine Coastline - Fjords and Estuaries
Objective 1. Understand long-term changes in the physical and chemical features of coastal habitats. • What are annual trends in salinity and other nearshore marine water quality parameters? • How is the relative composition of nearshore marine habitats changing (physical morphology and biotic communities)?
Objective 2. Understand how key marine species and communities are responding to changes in habitat. • Is the distribution of coastal salt marshes changing, or are vegetation zones within salt marshes migrating? • How does the distribution and relative abundance of marine mammals fluctuate spatially or temporally? • How are species that live in the supratidal but forage in estuaries and the intertidal changing with respect to distribution and abundance? • Are key species successfully reproducing?
Aquatic Systems - Large Rivers and Lakes
Objective 1. Understand long-term changes in the physical and chemical features of large rivers and lake systems. • How is water quality, including temperature, dissolved oxygen, conductivity and pH, changing spatially and temporally within large lake systems? • How are the thermal dynamics of large lakes changing in relation to the duration or lack of winter ice cover? • How are seasonal discharge and sediment regimes of rivers shifting? (i.e., higher winter flows and lower spring and summer flows?)
Objective 2. Understand how ecological relationships are changing in rivers, lakes, and wetlands. • How are lake processes responding to climatic warming? • How is anadromous salmon abundance and spawning distribution changing? • How is the composition and abundance of resident lake fish changing?

(continued on next page)

Table 1-4 (continued)

Ecoregion and Biological Diversity
Objective 1. Document rates and types of change in vegetation in response to environmental factors and human effects.
• How are plant and animal communities changing across the SWAN region in response to the primary environmental drivers of climate, natural disturbances, biotic interactions, and human activities?
Objective 2. Observe and understand ecological relationships and how the occurrence and distribution of fauna species and communities are changing.
• Are species range shifts occurring, and are they occurring evenly among habitats?
• Do nonnative species occur, and is their distribution increasing?
• How is the composition of bird and mammal communities changing?
Wilderness Dependent Wildlife and Species Interactions
Objective 1. Understand how species sensitive to humans are responding to habitat fragmentation, harvest, and increased human presence within or near parks.
• How are the distribution and/or relative abundance of large and medium sized carnivores changing?
• How are assemblages of carnivore prey species and vegetation communities changing temporally and spatially?
• How is habitat connectivity changing for wide ranging wilderness species such as wolves?
Human Activities
Objective 1. Understand how park and preserve ecosystems are affected by local and regional human activities.
• How are methods and locations of human access changing?
• How are visitor numbers and activities changing, and which resources are at risk from these changes?
• What land developments are occurring near and on park lands, and how do these affect park resources?
• Are hydrocarbons and other toxins bioaccumulating in marine invertebrates or freshwater fish?
Objective 2. Understand how park and preserve ecosystems are affected by global human development activities.
• How are network ecosystems responding to global climate change?
• How are far field human development activities affecting air and water quality in and surrounding network parks?
• Are atmospherically deposited or biotransported pollutants, such as PCB's and methyl mercury accumulating in fish; and do their concentrations show geographic gradients?

1.8 Conceptual Foundation for Monitoring

SWAN embodies a vast, diverse, and dynamic landscape that changes through space and time in response to inputs of energy, natural events, and the influence of humans. Monitoring at such large geographic scales requires a framework for understanding relationships between components and processes of interacting ecosystems and the human activities that affect them. For example, to understand how park ecosystems respond to adverse effects arising from human activities we need to be able to distinguish between changes that fall within and outside the range of natural variability. This requires scientifically sound information on ecosystem status and trends acquired through long-term monitoring. Short-term monitoring provides an incomplete picture because annual fluctuations may reflect variables that cycle through decades such as precipitation patterns, temperature regimes, or predator and prey populations. This is particularly true in subarctic regions, such as in southwest Alaska, where biological processes are relatively slow. In consideration of this, our conceptual foundation provides a guide for monitoring and research.

Conceptual Foundation for Monitoring
SWAN and its surrounding landmass, glaciers, lakes, rivers, and marine coastline are an interconnected landscape. Within this interconnected whole, at time scales of years to decades, climate, natural disturbance, biotic interactions, and human activities are the most important driving forces in determining ecosystem structure and function. Consequently, our monitoring program must address the interplay of multiple forces, which occur at a variety of spatial and temporal scales, in order to understand the structure and function of network ecosystems.

1.8.1 Landscape-Based Monitoring: Why Is It Important to Have a Landscape Perspective?

Theories developed to support studies of ecosystems are different from those that form a basis for studies of the ecology of landscapes (Sanderson and Harris 2003). A key difference is that time and space are rarely independent variables in ecosystem studies, even in watersheds. The SWAN landscape is a heterogeneous land area composed of interacting ecosystems that differ structurally in the distribution of species, communities, energy, and materials. This perspective is important for park managers in that the organisms that can exist (including their movement patterns, interactions, and influence on ecosystem processes) are constrained by the sizes, shapes, and patterns of interspersion of habitat across the landscape.

"Anyone who has visited a national park would agree that although a rotting log might be an ecosystem, it hardly qualifies as a landscape." (Sanderson and Harris 2003)

Landscape ecology is a science that explores how a heterogeneous combination of ecosystem attributes is structured, functions, and changes. Four principles of landscape ecology have particular importance for long-term monitoring in large Alaska national parks. These landscape principles deal with *time, place, disturbance,* and *species.*

a) Time Principle—Ecological processes function at many time scales, some long, some short; and ecosystems change through time. The time principle has several important implications for monitoring. First, the current composition, structure, and function of park ecosystems are, in part, a consequence of historical events or conditions that occurred decades to centuries to millennia earlier. Second, the full ecological effects of human activities often remain unseen for many years because of the time it takes for a given action to propagate through components of the system. Finally, the imprint of natural disturbance or a land use may persist

"Because we are unable to directly sense slow changes . . . processes acting over decades are hidden and reside in 'the invisible present.'" (Magnuson 1990)

on the landscape, constraining processes or species occurrence and abundance for decades or centuries (Dale et al. 2000).

We need to understand how the temporal dynamics of landscape change in parks affects ecological structure and processes. Short-term ecological events that we see every day often have their origins in transient, rare, slow, or subtle processes. Similarly, ecosystem response to natural and human-induced events may be cyclical, directional, episodic, or catastrophic. It is extremely difficult for humans to sense changes occurring over decades. Magnuson (1990) coined the term "the invisible present" to refer to the loss of information and tendency for misinterpretation when we fail to observe the present in appropriate time scales.

In the invisible present one finds time scales of the invasion of nonnative plants and animals; bioaccumulation of toxins, such as mercury; shifts in metapopulation dynamics of large mammals; and carbon dioxide-induced global climate change. These and other events move too slowly to be appreciated in real time, yet their accumulation results in real change over decades.

In the past, natural resource research and management in Alaska parks has been characterized by short-term (1–3 year) projects, and in most cases, frequent staff turnover. Short-term projects or breaches in continuity associated with park staff turnover confound interpretation of annual fluctuations in populations that may reflect such variables as precipitation patterns, temperature regimes, predator populations, or natural cycles.

***b) Place Principle*—**Local climatic, hydrologic, edaphic, and geomorphologic factors as well as biotic interactions strongly affect ecological processes and the abundance and distribution of plants and animals at any one place. Local environmental conditions reflect location along gradients of elevation, temperature, salinity, longitude, and latitude and the multitude of mesoscale physical, chemical, and edaphic factors that vary within these gradients. Hence, a rocky shoreline in KEFJ looks very different and has a different biotic community structure than a rocky shoreline at LACL.

> *"Even though . . . site-specific trends enhance our ecological insights, they rarely answer many questions of significance about larger . . . systems."*
> (Urquhart et al. 1998)

Ecological systems are characterized by multiple drivers acting at multiple scales, complex patterns of spatial variability, and unidentified thresholds. Because ecological processes and responses depend on the spatial context of an observation as well as on its temporal context, the analogy of an "invisible place," as with the invisible present, may be appropriate.

Park resource studies are often conducted at small spatial scales due to logistical constraints and costs, and often in response to management issues that are perceived to be localized. In field surveys, park biologists often make observations at different sites with the aim of relating biological response variables (i.e., the abundance of a species or the structure of an ecological community) to environmental variables. However, the ability to take a Network-wide view is important because when the same system is observed at several spatial scales, completely different characteristics in the distribution of organisms can be revealed (Turner et al. 1989).

Reciprocal relationships often exist among landscape structure and composition and ecological processes (Dale et al. 2000). To understand the relation between pattern and process requires that we move beyond simple descriptions at local scales to an assessment at multiple spatial scales. For example, monitoring programs that target a few parameters or a single entity, such as moose (*Alces alces*) distribution or seasonal snow cover, have limited value for understanding ecological processes, modeling, forecasting change, and developing scenarios to protect park resources. By monitoring a range of physical, chemical, and biological variables through time, it is possible to gain an understanding of how ecosystems function and respond to change. Additionally, coupling monitoring with research and modeling makes it possible to predict what might happen in the future and, where possible, devise appropriate management response strategies.

c) Disturbance Principle—It is imperative that we understand, and in some cases quantify, the drivers of change in ecological systems. These drivers include both ongoing natural processes, such as weather and interannual climatic variability, and random disturbances. Understanding the importance of the influence and magnitude of different drivers of change, the collective influence of multiple stresses, the ecological consequences of the changes, and the feedbacks between ecosystems and their physical environments (e.g., composition of the atmosphere or ocean, land use, water quality, sediment flux) is critical to the development of strategies for monitoring.

Figure 1-4 *Eruption of Mount Redoubt in LACL in 1990.*

A disturbance is an event that disrupts ecological systems, changes landscape patterns, and can impose both temporal and spatial heterogeneity on ecological systems. Disturbance events are usually episodic, such as avalanches or wildfires, or stochastic (random), such as earthquakes or volcanic eruptions (Figure 1-4). Episodic disturbances are part of the natural variability of a system, whereas stochastic disturbances change the trajectory of a system and may promote changes outside natural variability.

Disturbance has many important effects on communities and ecosystems, including enhancing or limiting biological diversity, initiating succession, and creating landscape patterns that influence many ecological factors, from movements and densities of organisms to functional attributes of ecosystems (Forman 1995).

Figure 1-5 *The recent discovery of giant kelp (Macrocystis pyrifera) along the Kenai Fjords coast during 2002 is an example of the importance of the "species principle." Giant perenial kelp is a north Pacific endemic limited in distribution by winter sea surface temperatures. The species may have been transported from Southeast Alaska on commercial herring nets and accidentally introduced. Its survival may indicate winter warming in the northern Gulf of Alaska. This species can act as a keystone in rocky shore communities by providing structure and food for a variety of other species.*

Major natural disturbances, such as earthquakes and volcanic eruptions, can have sudden and widespread effects on Network parks. The concept of *geoindicators* describes common earth processes that, in less than a century, are liable to change in magnitude, direction, or rate, enough to affect ecosystem condition and landscape structure (Berger and Iams 1996). Twenty-three of the 27 earth system processes and phenomena named as geoindicators are operative in SWAN. In addition, human-induced disturbances, such as oil spills, have similar potential to exert sudden, widespread, and long-lasting change.

d) Species Principle—Species respond to change, signal change, or directly affect ecological systems and landscapes in diverse ways (Figure 1-5). *Indicator species* (such as harbor seals, *Phoca vitulina*) are important because their condition indicates the status of a larger functional group of species, reflective of the status of key habitats, or symptomatic of the action of a stressor. *Keystone species* (such as sea otters, *Enhydra lutris*) have greater effects on ecological processes than would be predicted from their abundance or biomass alone (Power et al. 1996). *Ecological engineers* (such as beavers, *Castor canadensis*) alter the habitat and, in doing so, modify the fates and opportunities of other species (Naiman and Rogers 1997). *Umbrella species* (such as brown bears) either have large area requirements or use multiple habitats and thus overlap the habitat requirements of many other species. *Link species* (such as sockeye salmon, *Oncorhynchus nerka*) exert critical roles in the transfer of matter and energy across trophic levels or provide critical links for energy transfer within complex food webs. Trophic cascades occur when changes in the abundance of a focal species or guild of organisms at one trophic level propagate across other trophic levels, resulting in dramatic changes in biological diversity, community composition, or total productivity.

Changes in the abundance and distribution of focal species are diverse and can affect ecosystems through such processes as competition, mutualism, dispersal, pollination, and disease and by modifying habitats and abiotic factors. For example, brown bears are an important vector for transferring marine nutrients to riparian forests, through dissemination of partially eaten salmon carcasses and salmon-enriched wastes (Ben-David et al. 1998, Hilderbrand et al. 1999a). To the extent that this process affects productivity and species composition in riparian forests, interactions of salmon and bears may be characterized as keystone interactions controlling the long-term structure and dynamics of riparian communities (Helfield and Naiman 2002).

Because effects of keystones are diverse and involve multiple steps, they are often unexpected despite their fundamental importance to biological diversity and ecosystem dynamics (Paine 1995, Power et al. 1996). The depletion or removal of a keystone species can radically change the diversity and trophic dynamics of a system. Changes in land use that affect keystone species may spread well beyond the boundaries of a land-use unit. Because SWAN parks adjoin state, Native American, and private lands, developments or management actions taken outside parks may create habitats unfavorable to some species and favorable to others, create barriers to movement or dispersal, introduce new predators or competitors, or change existing trophic relationships.

A nonnative species can assume a focal-species role when introduced into an ecosystem and produce numerous effects on it. Nonnative species have altered community composition and ecosystem processes via their roles as predators, competitors, pathogens, or vectors of disease and through effects on water balance, productivity, and habitat structure (Drake et al. 1989).

1.8.2 Issues-Oriented Monitoring: What Are the Most Important Management and Scientific Issues in the Network?

To achieve success and continued support, long-term monitoring must provide data that are both useful and widely used. The data must be relevant to topics of widespread interest, as well as those of specific management concern. Most importantly, the information generated from the monitoring program needs to assist park managers in clarifying and addressing resource protection issues.

As used in this plan, “issues-oriented monitoring” implies that some park resources by virtue of legislative mandate, importance to stakeholders, or risk from a specific threat may receive attention beyond that which would emerge from their ecological position of importance in the landscape. It *does not* imply that monitoring will only focus on a narrow range of issues perceived to be relevant to today’s management challenges. The Network’s monitoring program simply cannot address every resource management interest. Limitations exist because institutional resources devoted to monitoring practices are often constrained by time, finances, and personnel.

The intent of the program is to monitor a select set of ecosystem processes and components that reflects the status of Network ecosystems and is relevant to resource protection issues. This information will collectively provide a foundation for understanding the parks and building a more flexible monitoring program. Future issues may emerge as monitoring proceeds and our understanding of ecological processes is enhanced.

As part of this process, past and current monitoring efforts within the parks were summarized (Table 1-5). Network park resource protection issues were compiled from former and current management plans, review of published and unpublished literature, and interviews with current and former park staff. Additionally, park resources staff developed a list of natural resource management issues or natural resources of special concern (current and anticipated). They also identified the basis for concern, if known, by identifying human-caused or environmental threats with the potential to affect park resources adversely. Issues were compiled and summarized under the headings of *Physical Change, Biological Resources, Pollution, and Human Use* (Table 1-6). This matrix was presented and discussed at scoping workshops attended by Regional NPS staff and scientists from other state and federal agencies. A recurring theme among issues is a lack of information. This is not surprising, given the vast size and complexity of the park units, brief history of their resource management programs, and relatively small staff and budget.

Park units in the Network share many of the same resource protection issues because of similarity in landscape features, geographic proximity, type and magnitude of public use, and enabling legislation. Most protection issues are linked to human population growth and the many ways that human activities are manifested in ecosystem response at the global, regional, network, and park scales. In Chapter 2, resource protection issues and concerns of Network parks are discussed under the headings of *far-field* (global/regional) and *near-field* (network/park). Conceptualizing near-field and far-field human effects is a challenging task because the scales are linked and environmental changes are not evenly distributed across the earth. Far-field human-related issues are manifested as climate change, long-distance air pollution, and demand for fossil fuels and other minerals. Near-field human-related issues are manifested as harvest of plants and animals, recreational use, and private lands development.

Table 1-5 *Summary of past and current monitoring in SWAN parks.*

	ANIA/ALAG/KATM	KEFJ	LACL
Air and Climate			
IMPROVE	NSF, NPS		**USFWS**
Weather		**Park**	**Park, NWS**
Snow	**Park**	**Park**	**Park**
Geology and Soils			
Glaciers		**Park, USGS**	CRREL
Water			
Stream Gauge		**Park, NWS**	**USGS***
Water Quality			**USGS***
Biological Integrity			
Insect and Disease	**ADNR**		**ADNR**
Salmon	**ADF&G**	**ADF&G**	**ADF&G, USFWS**
Bald Eagle	Park	Park	**Park**
Landbird	Park		
Trumpeter Swan			Park
Oystercatcher		Park	
Snowshoe Hare	Park		
Beaver			Park
Moose	**Park**		**Park**
Bear	**Park**		
Dall Sheep			Park
Mountain Goat		Park	
Stellar Sea Lion	**NMFS**		
Harbor Seal	**NMFS**	**Park, ASC**	
Vegetation		Park	
Human Use			
Visitor Use		**Park**	

Bold are currently monitored
* Park or Network funded

ADF&G = Alaska Department of Fish and Game
ADNR = Alaska Department of Natural Resources
ASC = Alaska Sealife Center
CRREL = United States Army Cold Regions Research and Engineering Lab
NMFS = National Marine Fisheries Service
NSF = National Science Foundation
NWS = National Weather Service
USFWS = United States Fish and Wildlife Service
USGS = United States Geological Service, Water Resources Division

Table 1-6 *Summary of natural resource protection and management issues in SWAN parks.*

	ANIA	KATM/ALAG	KEFJ	LACL
Pollution				
Airborne pollution or visibility	X	X	X	X
Noise pollution		X	X	X
Water pollution: bacterial, fuel emissions, fuel spills	X	X	X	X
Biological Resources				
Internal and external and developments that threaten habitat connectivity and animal movement corridors	X	X	X	X
Loss of community diversity, especially sensitive species and consumptive harvests (sport and subsistence)	X	X	X	X
Wildlife disturbance and displacement	X	X	X	X
Insect outbreaks	X	X	X	X
Exotic species introductions	X	X	X	X
Disruption of natural predator/prey interactions	X	X	X	X
Degradation of aquatic ecosystems	X	X		X
Alteration of trophic interactions in large lake systems	X	X		X
Depletion of salmon populations and effects on aquatic and terrestrial ecosystems	X	X	X	X
Changes in the composition, structure and function of intertidal biota related to climate change and pollution	X	X	X	X
Physical Change				
Soil erosion—human effects	X	X	X	X
Change in water chemistry	X	X	X	X
Change in climate: glacier changes, soil temp/permafrost changes	X	X	X	X
Volcanic eruptions	X	X		X